RESEARCH DEPARTMENT

LONG DISTANCE OVERLAND PROPAGATION MEASUREMENTS AT 180·4 Mc/s

Report No. K-140

(1959/23)

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SUMMARY

This report presents the results of field strength measurements of v.h.f. transmissions on 180·4 Mc/s overland paths at distances up to 294 miles (473 km). These measurements extended over a period of approximately 3½ years and have been used in the preparation of field strength/distance curves for various percentages of the overall time.

The measurements have been used by Study Group V of the C.C.I.R. in the preparation of field strength curves for tropospheric propagation at distances beyond the horizon.

1. INTRODUCTION

To operate common channel v.h.f. transmitters with the minimum amount of mutual interference information is required on the magnitude and duration occurrence of signals propagated over long distances.

Long distance propagation tests were started by the B.B.C. Research Department in 1947 and measurements have been made since then within the frequency range of 30-300 Mc/s.[1,2,3,4] The earlier measurements were made on frequencies in use by the B.B.C. between 40 Mc/s and 100 Mc/s. An extension of the television service was planned in Band III and, because of the B.B.C.'s interest in this band, experiments were started to determine how long distance tropospheric propagation was dependent upon frequency, and to obtain comparison with the results of the earlier tests.

In 1951 the C.C.I.R. began a Study Programme[5] with the aim of studying tropospheric wave propagation at distances well beyond the horizon and measurements made by the B.B.C. have contributed to this programme. Further information on higher frequencies was required to supplement the data already available in the United Kingdom and other countries. This report covers the measurements made on 180·4 Mc/s during the period from July 1954 to February 1958.

A basic requirement for an experiment of this nature is that the duration of the continuous recordings must be for as long a time as possible so as to embrace all periods of abnormal propagation. The above period of about 3½ years fulfils this requirement reasonably well.

2. TRANSMISSION PATHS

It was originally proposed to use two transmitters on slightly different frequencies, one sited at Holme Moss and the other at Sutton Coldfield. By carefully choosing the positions of the receiving sites and by using two receivers at each site it would have been possible to receive signals over six transmission paths with only three receiving sites. The receiving sites chosen were at Mursley in Buckinghamshire, Kingswood Warren, and Beddingham, near Lewes in Sussex, providing path distances of from 62 miles (100 km) to 203 miles (326 km).

Unfortunately, the transmitter at Holme Moss was required for other purposes and tests were started from the Sutton Coldfield transmitter only. The Sutton Coldfield transmissions continued from July 1954 to November 1956, the maximum path distance being limited to 147 miles (237 km). In order to extend the distance the transmitter was later removed from Sutton Coldfield and installed at Pontop Pike. The receiving sites remained at Mursley, Kingswood and Beddingham, and two further receiving points were added, one at Ottringham, near Hull, and another at Dorket Head, near Nottingham. Measurements were now made over path distances of from 107 miles (172 km) to 294 miles (473 km). The transmissions from Pontop Pike started in January 1957 and continued to February 1958.

Fig. 1 shows the geographical distribution of the transmitting and receiving sites.

3. APPARATUS AND SITES

3.1. Transmitter

The transmitter was designed for operation in Band III and operated on a carrier frequency of 180·4 Mc/s allocated exclusively for the experiments. The modulation, 100% square wave at a frequency of 1000 c/s, was cut automatically for 2 seconds every minute so that the signal could be identified at the receiving sites.

A four-element Yagi aerial was used for transmitting; it was erected first on the existing mast at Sutton Coldfield and later at Pontop Pike. At first the aerial at Sutton Coldfield was mounted at a height of 700 ft (213 m) above ground level but after 25th August 1955 it was lowered to 588 ft (179 m) above ground level because the upper part of the mast was required for the v.h.f. service aerial.

Details of the transmitting sites are given in Table 1.

TABLE 1

Transmitting Site Details

Station	Freq.	Period of Measurements	Effective Radiated Power	Site Height above mean sea level		Aerial Height above ground level		Latitude	Longitude	Aerial Polarization	Direction of Maximum Radiation
	Mc/s		Watts	ft	m	ft	m				
Sutton Coldfield	180·4	July 1954 to Nov. 1956	1000	555	169	588	179	52°35'59"N	01°49'57"W	H	143°
Pontop Pike	180·4	Jan. 1957 to Feb. 1958	1540	1002	305	390	119	54°52'08"N	01°46'11"W	H	164°

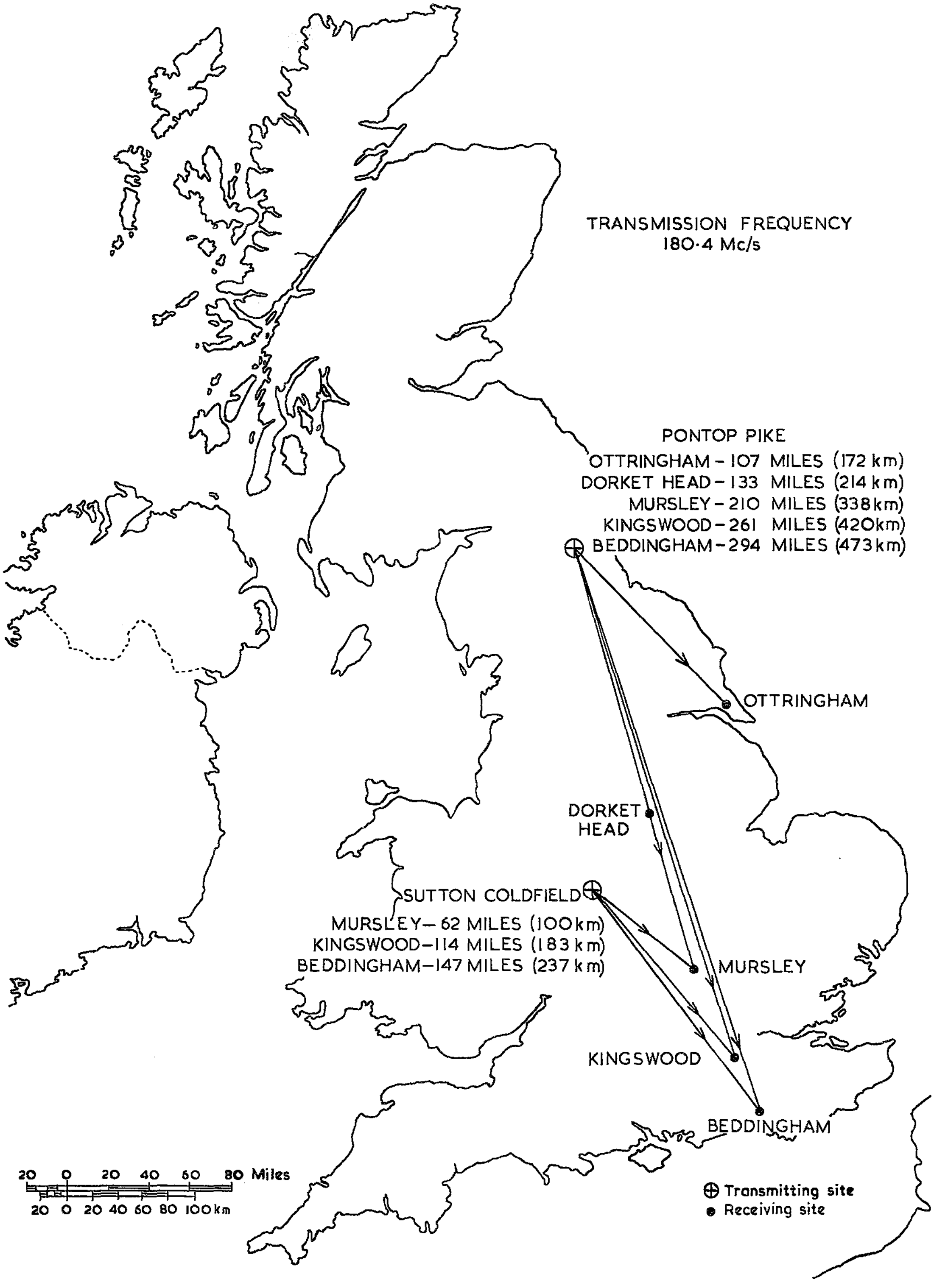

TRANSMISSION FREQUENCY
180·4 Mc/s
PONTOP PIKE
OTTRINGHAM - 107 MILES (172 km)
DORKET HEAD - 133 MILES (214 km)
MURSLEY - 210 MILES (338 km)
KINGSWOOD - 261 MILES (420 km)
BEDDINGHAM - 294 MILES (473 km)
OTTRINGHAM
DORKET HEAD
SUTTON COLDFIELD
MURSLEY - 62 MILES (100 km)
KINGSWOOD - 114 MILES (183 km)
BEDDINGHAM - 147 MILES (237 km)
MURSLEY
KINGSWOOD
BEDDINGHAM
20 0 20 40 60 80 Miles
20 0 20 40 60 80 100 km
⊕ Transmitting site
● Receiving site

Fig. 1 - Geographical distribution of transmitting and receiving sites

3.2. Receivers and Sites

The type of receiver used for these experiments has been described in detail in another Research Department report.[6] The main features of the receiver are its high sensitivity and stability of calibration. A high output signal/noise ratio is achieved by using 1000 c/s modulation at the transmitter and restricting the bandwidth of the circuits following the detector.

The receiving sites were initially chosen to meet the requirement of a range of distances over roughly similar terrain between 62 miles (100 km) and 203 miles (326 km). Easy access and the availability of suitable accommodation also influenced the choice.

When the transmitter was transferred to Pontop Pike two further receiving sites at Ottringham and Dorket Head were added.

Full receiving site details are given in Table 2 and Figs. 2 and 3 show the aerial and receiving installations at a typical site in Mursley, Buckinghamshire.

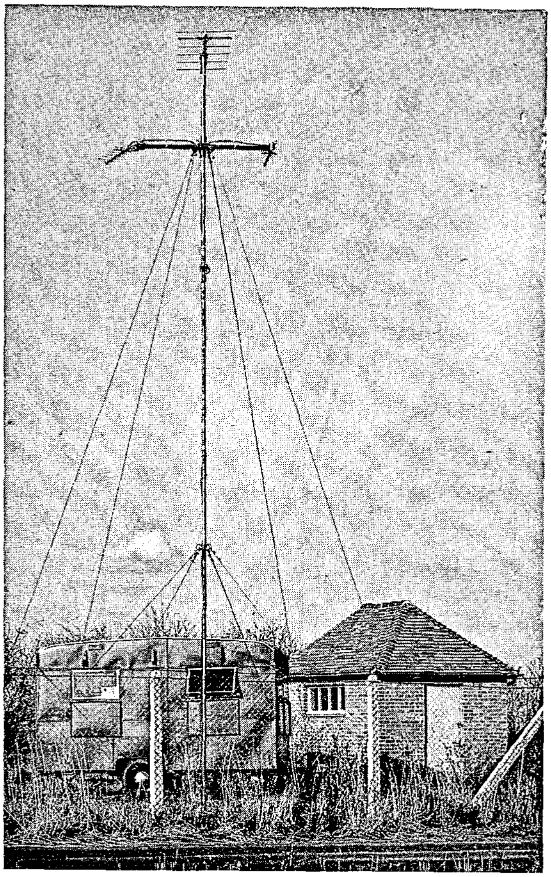


Fig. 2 - Caravan in situ at receiving site

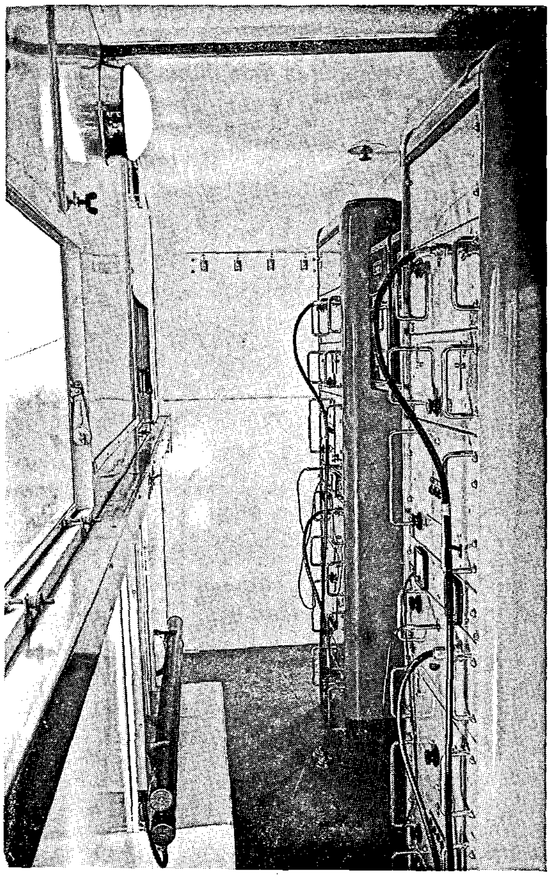


Fig. 3 - Typical equipment installation within the caravan

TABLE 2

Receiving Station	Transmitting Station	Receiving Site Details							Latitude	Longitude
		Distance of Receiving Site from Transmitter		Site Height above mean sea level		Aerial Height above ground level		Bearing of Site from Trans-mitter		
		miles	km	ft	m	ft	m			
Mursley	Sutton Coldfield	62	100	520	158	30	9·1	135°	51°57'12"N	00°48'05"W
Kingswood	"	114	183	550	167	30	9·1	142°	51°17'20"N	00°12'50"W
Beddingham	"	147	237	600	183	30	9·1	146°	50°50'02"N	00°04'15"E
Ottringham	Pontop Pike	107	172	30	9	30	9·1	139°	53°41'50"N	00°03'52"W
Dorket Head	" "	133	214	460	140	30	9·1	169°	53°01'02"N	01°06'48"W
Mursley	" "	210	338	520	158	30	9·1	169°	51°57'12"N	00°48'05"W
Kingswood	" "	261	420	550	167	30	9·1	165°	51°17'20"N	00°12'50"W
Beddingham	" "	294	473	600	183	30	9·1	164°	50°50'02"N	00°04'15"E

4. RESULTS

4.1. Analysis

The transmitter radiated from 0900-2300 hours daily and the field strength was recorded at each site during the whole of the period. Recording charts were run at speeds of 3 in. (7·6 cm) or 6 in. (15·2 cm) per hour depending on whether slow or fast fading was normally received.

The recordings were analysed daily. Each day was split into two periods, 0900-1800 hours and 1800-2300 hours in order to give an indication of any diurnal changes of signal strength. The daily analysis was grouped into months and finally the months were grouped to give the overall results. The analysis consisted of determining the time during which a signal was received at each of several fixed levels of field strength. These time durations, expressed as a percentage of the overall time, were then plotted against the signal level, separate graphs being prepared for each receiving site. The field strength for any required percentage of the overall time was then plotted against each of the distances at which the recordings were made and then a family of curves produced showing field strength against distance for 0·1%, 1%, 10% and 50% of the overall time.

4.2. Receiving Site Variation Factor

Receiving sites are often not representative of average reception in the area surrounding them. They may, as in the case of Beddingham, be sited on a hill dominating the surrounding area and may therefore be much superior to the majority of domestic receiving installations in that area.

To relate the field strength as measured at a given receiving site to the average field strength for the surrounding area, a correction factor has to be applied to the measured results. This factor is known as the "site variation factor" (s.v.f.). In practice, the site variation factor is estimated by choosing 15-20 sites within a 5 mile (8 km) radius of the fixed receiving site and comparing the measured fields with that at the fixed site. The ratio in dB of the field strength at each of the temporary sites to that at the fixed site is found and the mean of the ratios for all the sites gives the s.v.f. A negative s.v.f. indicates that the fixed site is superior to the average for the area.

The results of all the s.v.f. measurements made during the experiments are tabulated in the Appendix. These measurements were made on the Pontop Pike transmissions at all sites except Kingswood and Beddingham, where the signals were too weak for measurements to be made except during abnormal propagation conditions. The s.v.f.s for these two sites were therefore assumed to be the same as measured on the Sutton Coldfield transmission.

Table 3 gives the s.v.f. for each receiving site as measured on both transmissions. Mursley was the only receiving site where s.v.f. measurements were made on both transmissions and it will be seen that there is a difference of 3 dB. The s.v.f. for a given receiving site can therefore be different for different transmission paths.

TABLE 3

Receiving Site Variation Factor Results

Transmitter	Receiving Site	Site Variation Factor (s.v.f.) dB
Sutton Coldfield	Mursley	−8·0
	Kingswood	+5·5
	Beddingham	−13·5
Pontop Pike	Ottringham	−1·0
	Dorket Head	−1·5
	Mursley	−5·0

The results of the measurements to obtain the s.v.f. for the various receiving sites (see Appendix), are plotted in Fig. 4 in a way which shows the percentage number of receiving sites which are better or worse than the average site for each area. If the s.v.f. is known, then from Fig. 4 it is possible to find how the fixed site is representative of the area. For example, the s.v.f. for Kingswood (Sutton Coldfield) is 5·5 dB and from curve (a) it will be seen that 28% of the sites around Kingswood receive a worse signal from Sutton Coldfield than the site at Kingswood. Similarly, for Beddingham the s.v.f. = −13·5 dB and from curve (d) it will be seen that more than 99% of the sites in the area receive a lower field strength.

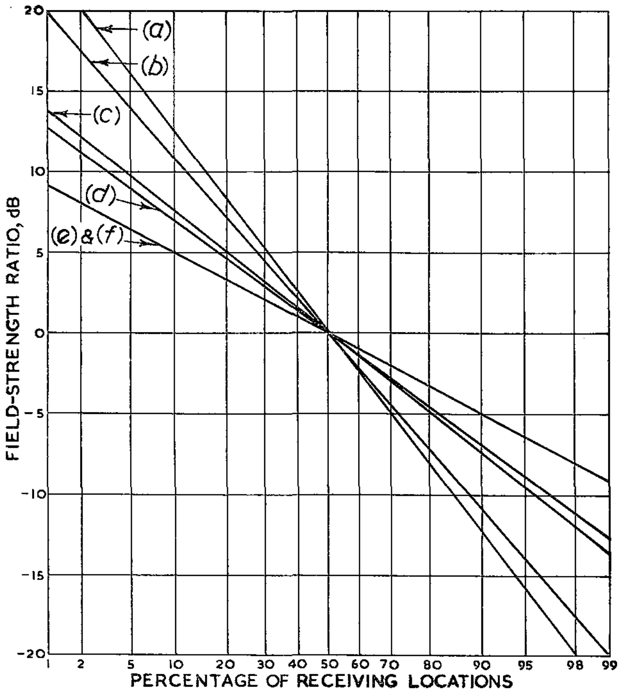


Fig. 4 - (a) Kingswood (Sutton Coldfield transmission)
(b) Mursley (Sutton Coldfield transmission)
(c) Dorket Head (Pontop Pike transmission)
(d) Beddingham (Sutton Coldfield transmission)
(e) Ottringham (Pontop Pike transmission)
(f) Mursley (Pontop Pike transmission)

4.3. Sutton Coldfield Transmissions

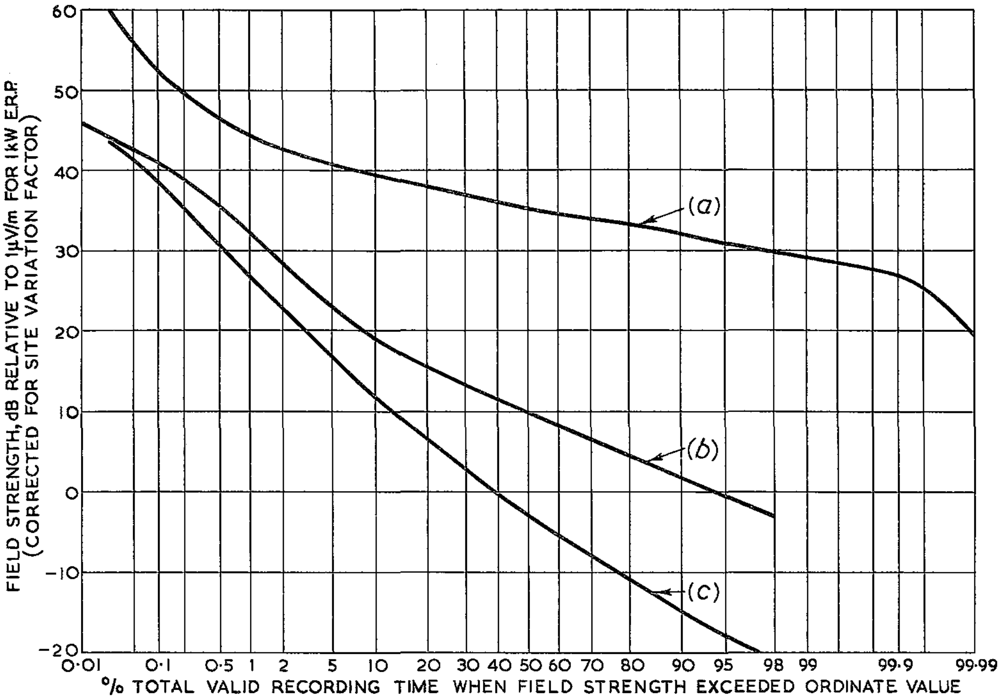
The Sutton Coldfield transmissions started in July 1954 and continued until November 1956. During this period, propagation conditions were sufficiently variable to give results which related to weather conditions normally experienced in the U.K.

Fig. 5 shows the results of the analysis of the measurements made at Mursley, Kingswood and Beddingham, plotted as field strength in terms of percentage time. The field strength values have been corrected by the s.v.f. for each site and for a radiated power of 1 kW from a half-wave dipole. Tabulated results, appropriate to certain fixed percentage times and with and without the s.v.f., are given in Table 4. It is of interest to note that if the measured results had been used for plotting Fig. 5 without using the s.v.f., the field strength at the further site (Beddingham) would be higher than that at a nearer site (Kingswood).

TABLE 4

Sutton Coldfield Results

Receiver	Measured field strength (dB rel. 1μV/m for 1 kW e.r.p.)							Field strength corrected for s.v.f. (dB rel. 1μV/m for 1 kW e.r.p.)						
	0·1%	1·0%	10%	50%	90%	99%	99·9%	0·1%	1·0%	10%	50%	90%	99%	99·9%
Mursley	60·5	52·5	47·5	43·0	40·0	37·0	35·0	52·5	44·5	39·5	35·0	32·0	29·0	27·0
Kingswood	35·5	26·5	13·5	4·5	−4·0	–	–	41·0	32·0	19·0	10·0	1·5	–	–
Beddingham	52·0	40·5	25·0	10·5	−1·5	−10·0	–	38·5	27·0	11·5	−3·0	−15·0	−23·5	–



CURVE	RECEIVER	DISTANCE		TOTAL HOURS RECORDED	FREE SPACE FIELD *
		miles	km		
(*a*)	MURSLEY	62	100	5243	66·9
(*b*)	KINGSWOOD	114	183	7487	61·6
(*c*)	BEDDINGHAM	147	237	7212	59·4

* dB rel. 1µV/m, for 1kW E.R.P.

Fig. 5 - Sutton Coldfield transmission — variation of field strength with time

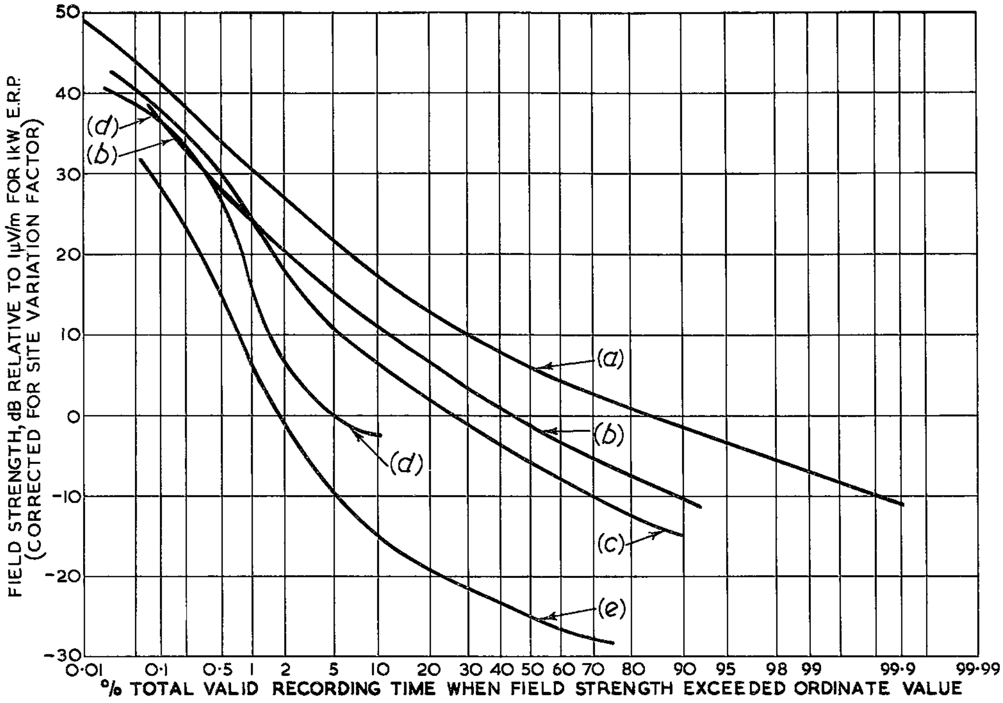
The receiving site at Mursley is only 62 miles (100 km) from Sutton Coldfield and the signal received there during normal propagation conditions is substantially constant, with only slight variation of signal level from day to day. During periods of abnormal propagation, however, the field strength increases appreciably and fades slowly with only very occasional "drop outs". The difference between the 0·1% and 50% time values is 17·5 dB, whereas between the 50% and 99·9% it is only 8 dB. On one occasion only the signal dropped to zero but this occurred for only a few seconds.

The signals received at Kingswood and Beddingham usually showed rapid fading with amplitude changes of the order of 20 dB. Only during periods of abnormal propagation was the signal at all steady at these sites and it then showed the slow fading characteristics.

4.4. Pontop Pike Transmissions

As stated earlier the transmission path was extended by transferring the transmitter to Pontop Pike but retaining the receiving sites at Mursley, Kingswood and Beddingham. Receiving sites at Dorket Head and Ottringham were included and transmissions started in January 1957 and continued until February 1958.

The analysed results of measurements taken at all of the receiving sites have been plotted in Fig. 6 which shows the levels exceeded for given percentages of the overall time. Table 5 is a tabulated list of measurements with and without correction for various percentages of the overall time.



CURVE	RECEIVER	DISTANCE		TOTAL HOURS RECORDED	FREE SPACE FIELD *
		miles	km		
(a)	OTTRINGHAM	107	172	4253	62·2
(b)	DORKET HEAD	133	214	3798	60·3
(c)	MURSLEY	210	338	4210	56·3
(d)	KINGSWOOD	261	420	3197	54·4
(e)	BEDDINGHAM	294	473	4157	53·4

*dB rel. 1µV/m, for 1kW E.R.P.

Fig. 6 - Pontop Pike transmission — variation of field strength with time

TABLE 5

Pontop Pike Results

Receiver	Measured field strength (dB rel. 1µV/m for 1 kW e.r.p.)							Field strength corrected for s.v.f. (dB rel. 1µV/m for 1 kW e.r.p.)						
	0·1%	1·0%	10%	50%	90%	99%	99·9%	0·1%	1·0%	10%	50%	90%	99%	99·9%
Ottringham	42·5	31·5	18·5	6·5	-0·5	-6·0	-10·0	41·5	30·5	17·5	5·5	-1·5	-7·0	-11·0
Dorket Head	38·0	26·0	12·5	0·0	-9·0	-	-	36·5	24·5	11·0	-1·5	-10·5	-	-
Mursley	43·0	29·5	11·0	-1·0	-10·0	-	-	38·0	24·5	6·0	-6·0	-15·0	-	-
Kingswood	31·0	11·0	-8·0	-	-	-	-	36·5	16·5	-2·5	-	-	-	-
Beddingham	42·0	20·0	-1·5	-11·5	-	-	-	28·5	6·5	-15·0	-25·0	-	-	-

An interesting fact can be seen in both Figs. 5 and 6 – it will be observed that the slope of the curves increases as the distance increases. This reveals that the fading range increases with distance.

It will also be seen that for the very low percentages of the overall time the signal strength is less dependent on distance. A possible explanation of this effect is that, for very short periods of time, meteorological conditions are such that the mode of propagation involved, at these frequencies, results in partial duct transmission or "trapping" and the signal is then less attenuated than under normal conditions.

The signals received at Ottringham, Dorket Head and Mursley were normally of the fast fading type and it was only during periods of abnormal propagation that the fading rate was slow with an accompanying increase in signal level. It was only possible to receive signals at Kingswood during periods of abnormal propagation and then the fading rate was slow. At Beddingham a weak, fast-fading signal could be received most of the time, but during periods of abnormal propagation this increased in level and changed to slow fading characteristics.

4.5. Field Strength/Distance Curves

All values of field strength in dB above 1 μV/m, corrected for s.v.f., are shown in Fig. 7 plotted against distance for 0·1%, 1%, 10%, 50%, 90% and 99·9% of the time. Best fit lines, calculated by the method of least squares, are drawn through the points relating to each time percentage value, with the exception of 99% and 99·9%

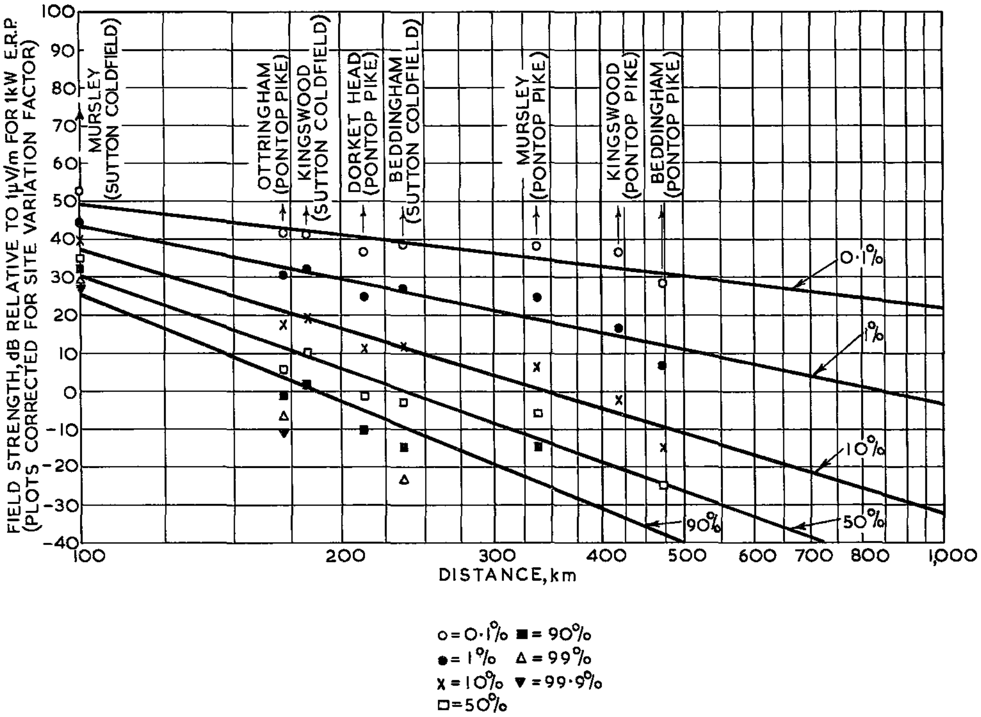


Fig. 7 - Variation of field strength (180·4 Mc/s) with distance for fixed percentage times

where the number of values is insufficient. Scatter of the points is quite small, a substantial improvement having been achieved by the s.v.f. correction, as an examination of Fig. 7 and Tables 4 and 5 will show. The logarithmic distance scale was also found to give better fitting lines than a linear distance scale. This implies an inverse power law relationship between field strength, E, with the distance, d, of the form: $E = k/d^m$ where k is a parameter related to the transmission path and to the power of the transmitter.

Table 6 gives the values of m and 20 log k for the Sutton Coldfield and Pontop Pike results together. It is interesting to note that m has a value approaching 5 in the case of the 90% curve and its value for the 0·1% curve is only 1·3, indicating a reduced dependence of the field strength on distance under conditions of abnormal propagation.

TABLE 6

Band III – Slope of Field Strength/Distance Curves

Percentage Time	Sutton Coldfield and Pontop Pike	
	m	20 log k (dB)
0·1%	1·351	103·4
1·0%	2·373	138·6
10%	3·488	176·8
50%	4·067	192·8
90%	4·727	214·9

The field strength/distance curves of Fig. 7 are replotted on linear paper in Fig. 8, together with the new C.C.I.R. curves covering the whole frequency range 30–600 Mc/s, as adopted at the IXth Plenary Assembly, Los Angeles, 1959. It will be seen that there are significant differences in the results compared with the information given in the C.C.I.R. curves, particularly at the long distance and for the 1% time value. It is not possible to account for these large differences; but it must be remembered that the C.C.I.R. curves are derived from the results of measurements over many transmission paths in several different countries while the results given in this report are the measurements on one frequency and in the U.K. only.

4.6. Monthly Field Strength Variations

The field strengths exceeded in each month for each percentage time are plotted in Figs. 9 and 10 for the transmission paths of Sutton Coldfield and Pontop Pike, respectively.

These curves show that there is a seasonal trend in the observed field strengths. There is a tendency for the signal to be higher in the winter months than in the summer, although at one site, Ottringham, the highest signal actually occurred in June 1957.

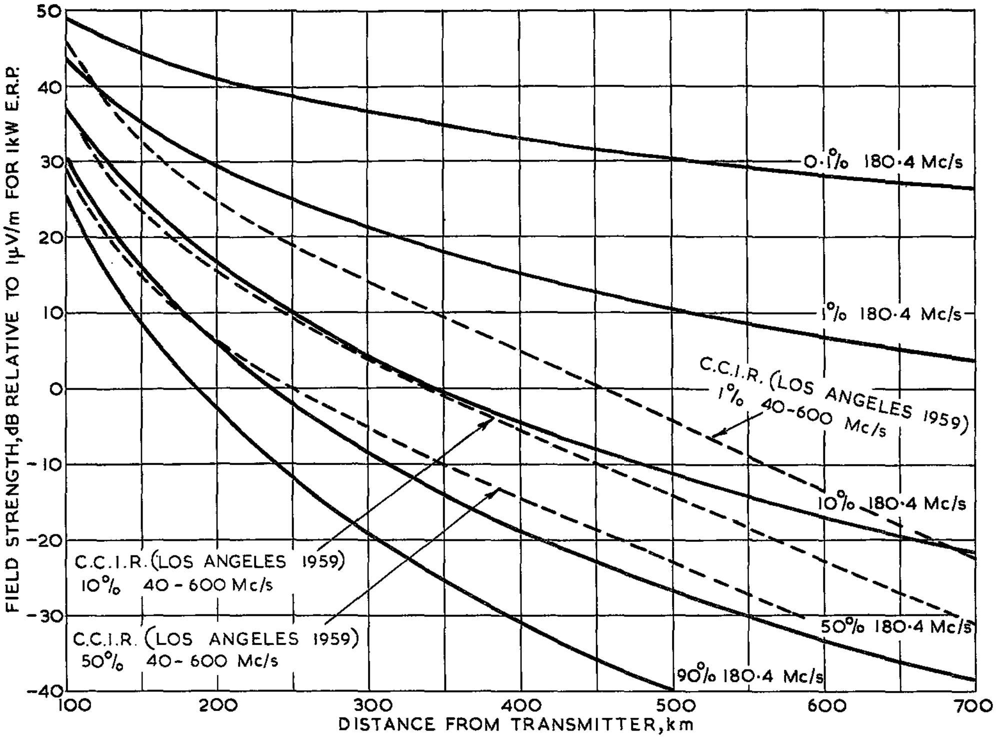


Fig. 8 - Comparison of 180·4 Mc/s field strength/distance curves with existing C.C.I.R. (Los Angeles 1959) curves

In general the high field strengths occurred at all the sites during the same months. An exception, however, is apparent in Fig. 9 where the Mursley field strength in December 1954 and May 1955 remained low, while there was a rise in field strength at Kingswood and at Beddingham.

Other features worth noting in Figs. 9 and 10 are that the month to month variations in field strength increase with increasing distance, and with decreasing percentage times. These points are more clearly demonstrated in Fig. 11, where the standard deviations of the field strength values in Figs. 9 and 10 are plotted as a function of distance for each percentage time and the best fit lines drawn. These show clearly that the month to month variations increase with distance for the 0·1% and 1% values, whereas for the 10% and 50% values they are practically independent of distance. The large standard deviations at the greater distances for the 0·1% and 1% field strengths emphasise the need for continuing the type of experiment discussed in this report for periods long enough to embrace the whole range of tropospheric variations, if reliable figures of field strength for the small percentage time values are to be obtained.

4.7. Anomalous Propagation

Abnormally high signals are usually received during anticyclonic weather conditions either in summer or winter. They are associated with discontinuities in the refractive index profile in the upper atmosphere.

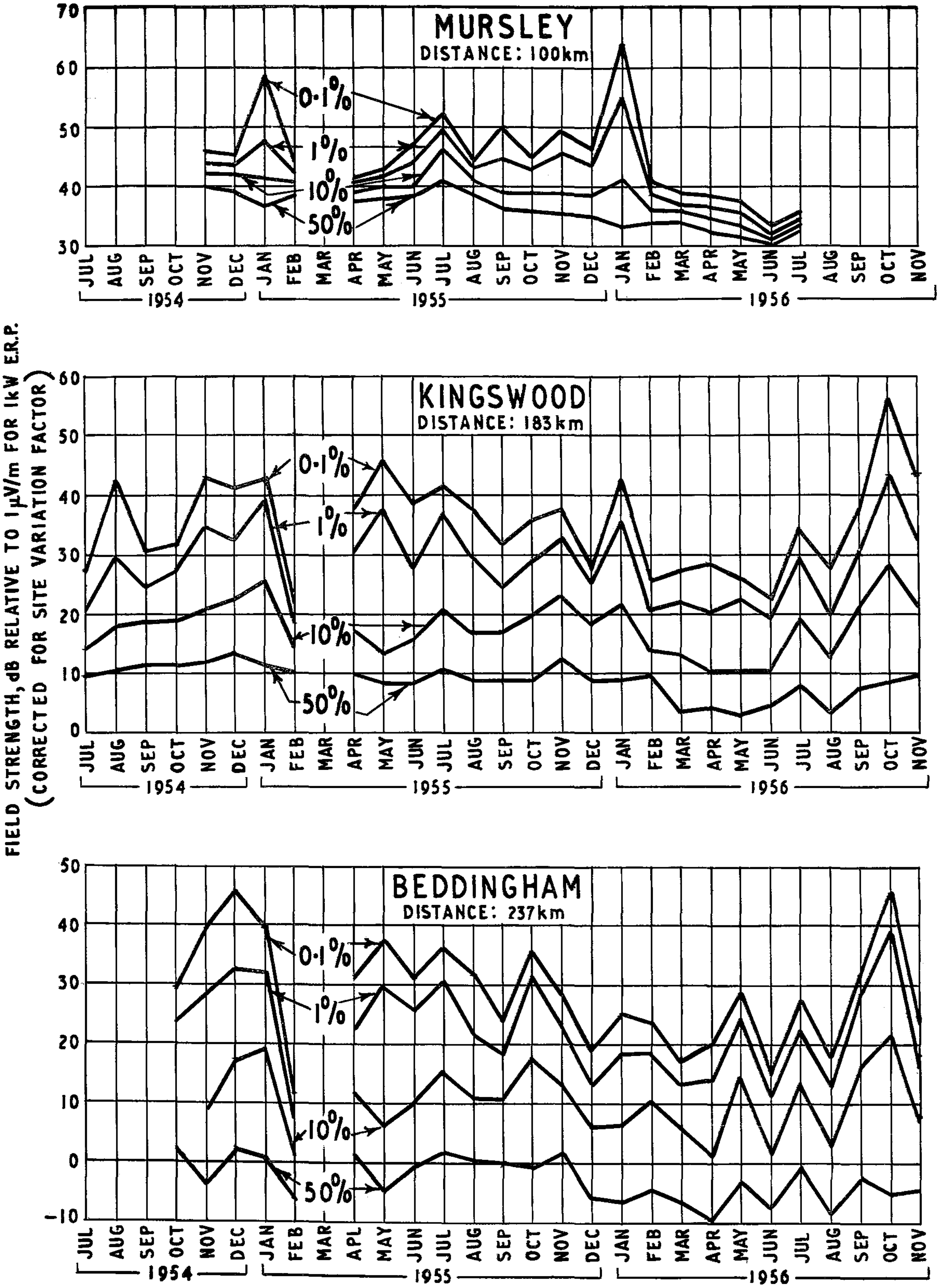
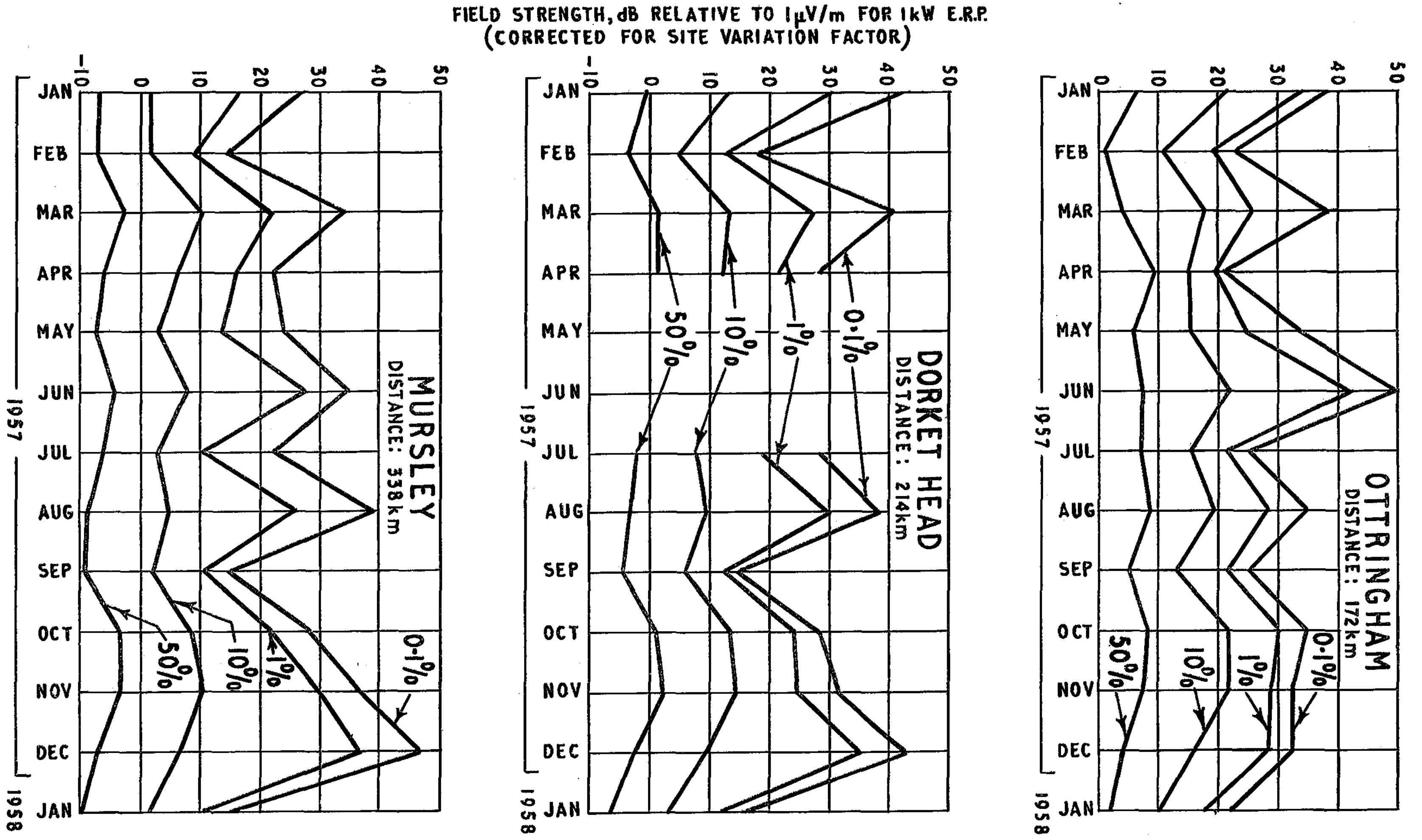


Fig. 9 - Band III (180·4 Mc/s) – Sutton Coldfield transmission.
Field strengths exceeded in each month for 0·1%, 1%, 10% and 50% of the time


FIELD STRENGTH, dB RELATIVE TO 1µV/m FOR 1kW E.R.P.
(CORRECTED FOR SITE VARIATION FACTOR)
OTTRINGHAM
DISTANCE: 172km
DORKET HEAD
DISTANCE: 214km
MURSLEY
DISTANCE: 338km
0·1%
1%
10%
50%
-10
0
10
20
30
40
50
JAN
FEB
MAR
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MAY
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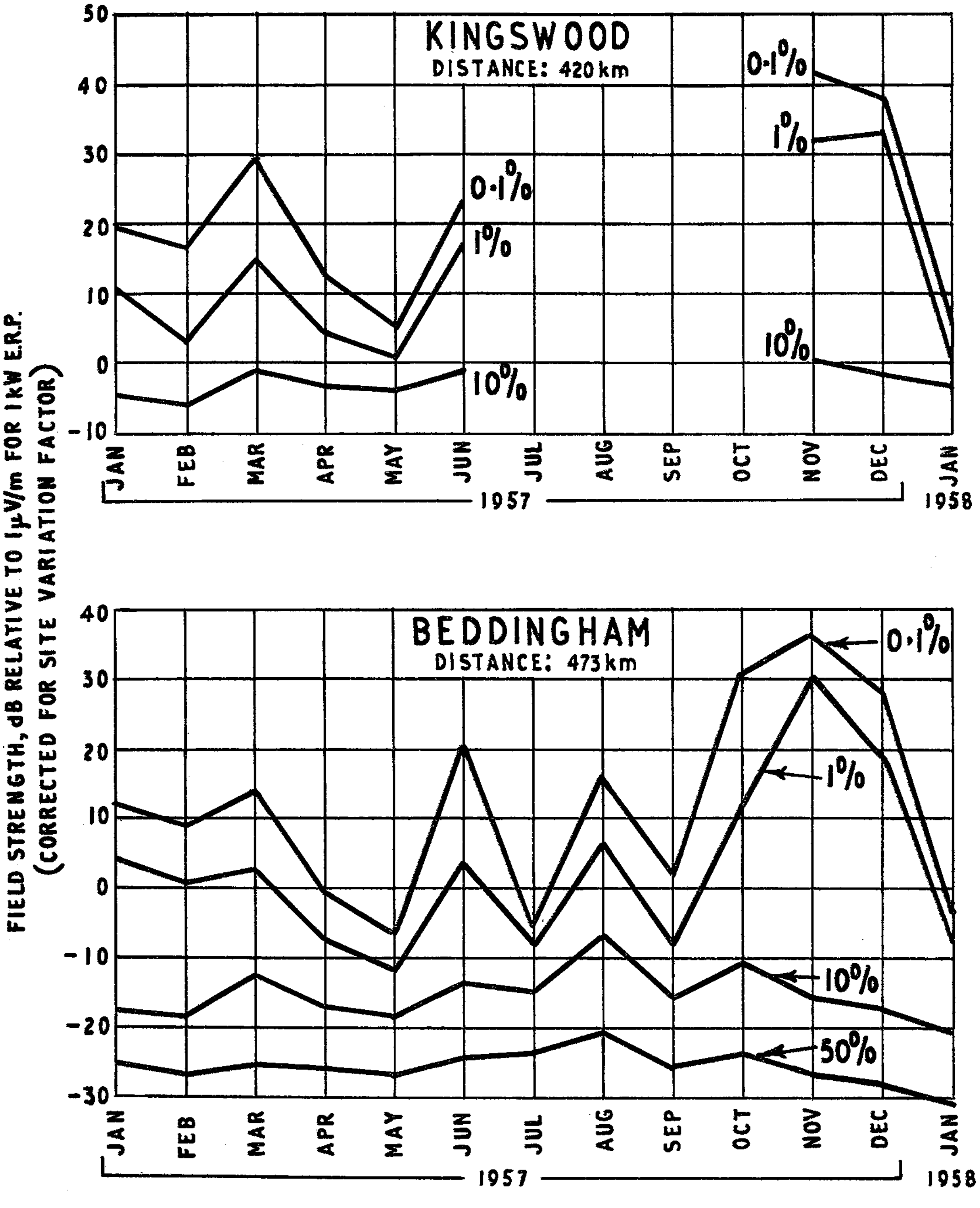


Fig. 10 - Band III (180·4 Mc/s) — Pontop Pike transmission.
Field strengths exceeded in each month for 0·1%, 1%, 10% and 50% of the time

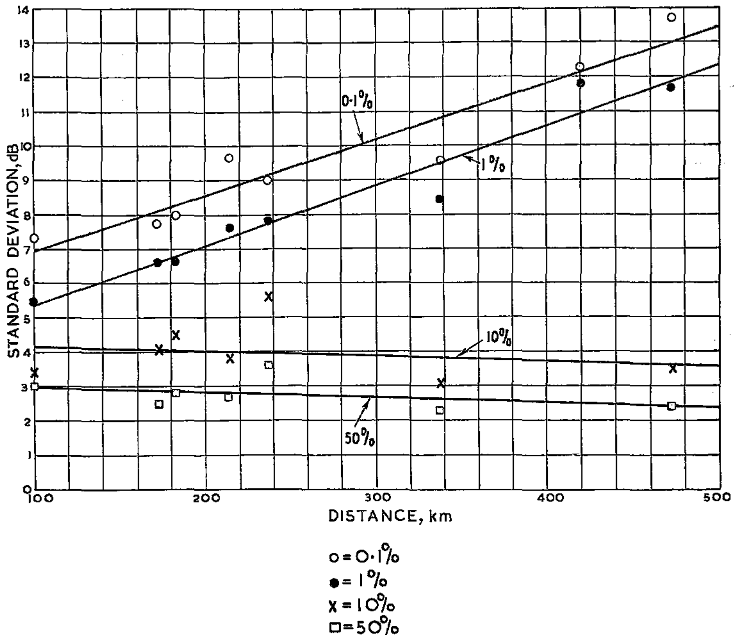
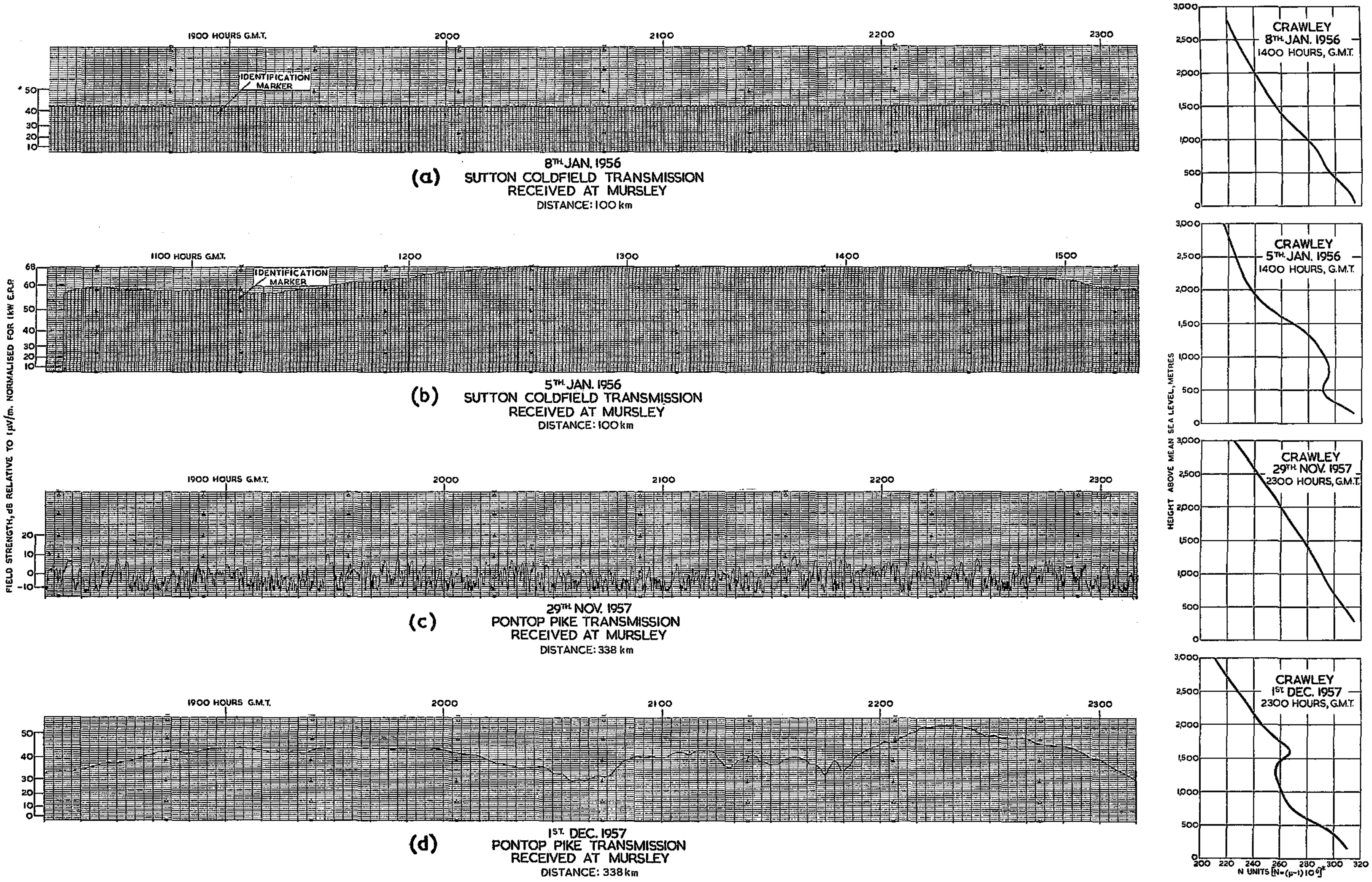


Fig. 11 - Band III (180·4 Mc/s) — Sutton Coldfield and Pontop Pike. Standard deviation of the field strengths exceeded in each month for different percentage times plotted against distance

Field strength records of the signal received at Mursley from both Pontop Pike and Sutton Coldfield during normal and abnormal propagation conditions are shown in Figs. 12 (a), (b), (c) and (d).

Fig. 12(a) is the record taken at Mursley on 8th January 1956, showing the type of signal normally received from Sutton Coldfield. It is a steady signal of 42 dB relative to 1 μV/m, the measured median signal for the whole period of the test being 43 dB. Fig. 12(b), the record of 5th January 1956, shows the type of signal received during conditions of abnormal propagation. The signal level at the start of transmission is 56 dB, rising to the full scale value of 68 dB by 1230 GMT and remaining above this level until 1420 GMT before dropping gradually to 58 dB at 1520 GMT. The peak value of this signal is not known as the full scale deflection of the recorder was exceeded but it is, however, estimated (from the nature of the fading characteristics) to be 72 dB, which is 5 dB greater than the free-space value. This signal is the highest ever observed at Mursley in the two-year period of the Sutton Coldfield tests. Another interesting feature is that the maximum signal occurred between the times 1230 and 1420 GMT. It is usual, especially at times of anomalous propagation, for the signals to be higher in the mornings and evenings than in the afternoons.

Figs. 12(c) and (d) show charts of the Pontop Pike measurements for 29th November and 1st December 1957. The normal signal is shown in Fig. 12(c) and the signal during abnormal propagation conditions in Fig. 12(d). It can be seen that the field strength at 1800 GMT is about 30 dB and thereafter, with slow fades, reaches the maximum in the late evening, at 2218 GMT. This is the more usual time for maxima to occur. The peak signal of 53 dB is the highest recorded during the Pontop Pike tests. In this instance the peak signal is 3 dB lower than the free-space value.



(a) 8TH. JAN. 1956
SUTTON COLDFIELD TRANSMISSION
RECEIVED AT MURSLEY
DISTANCE: 100 km

(b) 5TH. JAN. 1956
SUTTON COLDFIELD TRANSMISSION
RECEIVED AT MURSLEY
DISTANCE: 100 km

(c) 29TH. NOV. 1957
PONTOP PIKE TRANSMISSION
RECEIVED AT MURSLEY
DISTANCE: 338 km

(d) 1ST. DEC. 1957
PONTOP PIKE TRANSMISSION
RECEIVED AT MURSLEY
DISTANCE: 338 km

Fig. 12 - Examples of Mursley charts with the appropriate refractive index height profiles

An attempt has been made to correlate the field strength records of Fig. 12 with refractive index profiles derived from aerological records obtained from the Meteorological Office. The nearest meteorological station is at Crawley and, although rather far from the Sutton Coldfield or Pontop Pike/Mursley path, the information from this station has been used to calculate the refractive index profiles shown in Fig. 12. The times of the aerological data correspond to those of the field strength records with the exception of Fig. 12(a), in which case the aerological data for 1400 GMT were used. The charts for Figs. 12(a) and (c) are examples of records made when the conditions of propagation were normal, and in these cases the refractive index profiles vary approximately linearly with height. Figs. 12(b) and (d) are records taken when conditions were abnormal and it is seen from the profiles drawn by the side of these records that the refractive index profile on these occasions is non-linear. The discontinuity in Fig. 12(b) occurs at a height of 500 metres, while in Fig. 12(d) there are two that might be relevant, at 800 metres and 1300 metres. On 5th January 1956 and 1st December 1957 an anticyclone was centred over Germany and the Low Countries and a ridge of high pressure extended over most of the U.K. Widespread fog was prevalent over most of the transmission path.

5. CONCLUSIONS

The investigations described in this report were conducted over a land path at a frequency in Band III of 180·4 Mc/s. The gradients of the field strength/distance curves derived from the measurements decrease with decreasing percentage times, implying a decreasing influence of distance on the received field strength under abnormal propagation conditions.

The site variation factor improves the accuracy of the curves obtained, the scatter of the measured values being reduced by this correction.

The field strength exceeded each month for the various percentage times varies over a greater range as the percentage time decreases. Variation of the "0·1%" and "1%" field strengths also increases with increasing distance.

Abnormally high signals are experienced during anticyclonic weather either in summer or winter, when discontinuities in the refractive index of the troposphere occur at heights between 500 and 2000 metres. The highest signals during these experiments were generally recorded during the winter months and on days when fog was widespread over the transmission path. Signals received during periods of anomalous propagation approach, and may exceed, the free-space value.

6. ACKNOWLEDGEMENTS

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MV

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN MURSLEY AREA
TRANSMISSION FROM SUTTON COLDFIELD — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square SP)	Site Height (a.m.s.l.)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Oving	786218	500	152	5·0	8·0	+47·0	+42·5	+4·5	Approaching crest of hill. Concave ground in front. Low wires at roadside. Small trees on left and houses 300 yd in rear.
2	Gt. Horwood Common	777322	420	128	3·5	5·6	+46·0	+41·5	+4·5	Exposed site. Low telegraph wires at roadside. No trees within ¼ mile.
3	Soulbury	874268	450	137	3·5	5·6	+39·0	+41·5	−2·5	Exposed site. Country generally rising to Mursley 3 miles in front.
4	Whaddon	798344	350	107	3·5	5·6	+39·0	+41·5	−2·5	Clear site for 100 yd all round. Land falls slightly.
5	Gt. Horwood	783312	425	129	3·0	4·8	+38·0	+42·0	−4·0	No trees within 100 yd. Open country in front with scattered trees.
6	East Claydon	736254	400	122	5·9	9·5	+41·0	+45·0	−4·0	Open field with trees 100 yd in rear.
7	Adstock	737308	370	113	5·5	8·8	+36·0	+42·0	−6·0	Exposed site with low farm buildings immediately in front and tall hedgerow in rear.
8	Liscombe Park	883252	400	122	4·4	7·1	+31·5	+40·5	−9·0	Open area but thick trees 400 yd in front.
9	Thornton	762364	300	91	6·0	9·6	+32·5	+41·5	−9·0	Exposed site. Land falling at shallow angle in front.
10	Stoke Hammond	875297	320	97	3·3	5·3	+30·5	+41·5	−11·0	No large trees within 150 yd. Open ground in front.
11	Potash Farm	835278	470	143	1·0	1·6	+28·5	+41·5	−13·0	Open in front rising to crest of hill on which fixed site is situated, but trees within 200 yd.
12	Shenley Church End	831374	270	82	5·0	8·0	+27·0	+41·0	−14·0	Ground rising for 1 mile. Slight screening by trees.
13	Winslow-Bennetts Hill	779265	305	93	3·3	5·3	+26·5	+42·0	−15·5	Site in valley.
14	A.5. North of Bletchley	872348	250	76	4·5	7·2	+25·5	+41·5	−16·0	Open site beside main road. Telephone wires 60 ft on left in direction of transmitter site.
15	Newton Longville	839316	350	107	1·7	2·7	+23·5	+41·5	−18·0	Clear of trees for 200 yd but hill 2 miles in front.
16	Cublington	832214	330	100	4·7	7·6	+17·0	+41·0	−24·0	Site in valley. Some trees on ridge 1½ – 2 miles in front.
Fixed Site	Mursley	825291	520	158	–	–	Site Variation Factor −8·0 dB			Open site at crest of gradually sloping terrain.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW ERP)

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN KINGSWOOD AREA
TRANSMISSION FROM SUTTON COLDFIELD — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square TQ)	Site Height (a.m.s.l)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Epsom Golf Course	226589	450	137	2·25	3·6	+17·5	−3·0	+20·5	Level site near top of hill with terrain falling in direction of transmitter.
2	Banstead Crossroads	249605	400	122	3·0	4·8	+16·5	−2·5	+19·0	Open scrubland falling fairly rapidly in direction of transmitter.
3	Walton-on-the-Hill	220556	550	168	1·75	2·8	+13·25	−4·0	+17·25	Open site on hillside facing the transmitter.
4	Little Woodcote	283613	370	113	4·0	6·4	+12·0	−5·25	+17·25	Clear area with ground falling in front.
5	Headley Heath	205540	600	183	3·0	4·8	+14·5	−0·5	+15·0	Open level heath.
6	Crossways Farm	263534	625	190	1·75	2·8	+11·75	−0·25	+12·0	Few trees with falling ground in front for 1 mile and then rising.
7	Burgh Heath	241576	550	168	1·25	2·0	+6·25	−2·75	+9·0	Level open space with small trees and houses in front.
8	Pebble Coombe	208526	625	190	3·25	5·2	+4·5	+0·5	+4·0	Site restricted by low trees.
9	Coulsdon Common	316570	550	168	4·25	6·8	−0·5	−4·5	+4·0	Fairly level site slightly screened by trees at 300 yd distance.
10	Banstead	264591	500	152	2·25	3·6	−1·0	−3·75	+2·75	Level ground with small trees nearby. Built-up area ¾ -mile in front.
11	A24 North of Mickleham	169544	150	46	5·0	8·0	−2·0	−4·0	+2·0	Clear site save for 30 - ft trees.
12	Alderstead Heath	300551	550	168	3·25	5·2	−3·5	−5·0	+1·5	Small trees in vicinity. Ground falling slightly in direction of transmitter.
13	West Ewell	203634	100	30	5·5	8·8	−2·5	−3·0	+0·5	Slightly falling ground with trees one side of road and houses the other.
14	Hall Lands	298516	275	84	4·0	6·4	−7·0	−3·5	−3·5	Open common. Ground falls slightly then rises to 600 ft two miles in front.
15	Epsom	199608	200	61	4·25	6·8	−8·5	−1·75	−6·75	Level ground with 40-ft trees quarter of a mile in front.
16	Woodhatch Estate	259485	225	69	4·5	7·2	−12·5	−3·5	−9·0	Clearing in house estate with 350-ft hill ½-mile and a 650-ft ridge 2½ miles in front.
17	Brockham Green	196496	150	46	5·0	8·0	−13·0	−3·5	−9·5	Village green surrounded by small buildings with 650-ft ridge 1 mile in front.
Fixed Site	Kingswood	248559	550	168	–	–	Site Variation Factor 5·5 dB			Scattered trees 30 ft to 40 ft high in the vicinity of the site with 50-ft trees ¼-mile in direction of transmitter.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW ERP)

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN BEDDINGHAM AREA
TRANSMISSION FROM SUTTON COLDFIELD — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square TQ)	Site Height (a.m.s.l)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Glyndebourne	449110	240	73	3·0	4·8	+1·5	+6·5	−5·0	Near top of hill. Small trees nearby.
2	Chalvington	525091	50	15	4·5	7·2	−1·5	+4·0	−5·5	Clear site in centre of low plain.
3	Cradle Hill	509010	300	91	4·5	7·2	−10·0	−2·5	−7·5	Scrubland at side of main road. Facing hill on which permanent site stands, with hills at distances of 2½ and 4½ miles.
4	Malling Hill	424114	100	30	4·0	6·4	−6·0	+2·0	−8·0	Clear area on hillside facing transmitter site.
5	Sth. Heighton	453032	150	46	1·7	2·7	−1·5	+9·0	−10·5	On low chalk down with 250-ft hill 1½ miles in front.
6	Beddingham Hill	458067	250	76	0·5	0·8	−8·0	+3·0	−11·0	Open site on steep hillside facing transmitter site.
7	Telscombe	415045	250	76	2·8	4·5	−3·5	+8·0	−11·5	Open field falling to valley 50-100 ft a.m.s.l. then rising to 500 ft ¾ mile in front.
8	Peacehaven	427007	175	53	3·8	6·1	−5·0	+10·0	−15·0	Site by road facing hills 2½ miles across valley.
9	Cement Works	436065	50	15	1·5	2·4	−11·5	+3·5	−15·0	Side of valley. Clear path for 3 miles.
10	Little Stream Farm	503113	30	9	4·3	6·9	−9·5	+5·5	−15·0	Open field on plain.
11	Ringmer	454127	50	15	4·3	6·9	−7·0	+9·0	−16·0	Level ground with no immediate obstacles.
12	Kingston	392088	200	61	4·5	7·2	−8·0	+10·0	−18·0	Near top of chalk down. 400-ft hills on other side of valley.
13	Piddinghoe	435031	30	9	2·3	3·7	−9·0	+9·5	−18·5	Village green surrounded by small buildings.
14	Stonery Farm	518066	100	30	3·8	6·1	−14·5	+5·0	−19·5	Open field sloping towards transmitter site then rising to 130 ft at a distance of ½-mile.
15	Alfriston	514039	150	46	3·7	5·9	−11·5	+12·5	−24·0	Spurs of similar altitude ½ to ¾ mile ahead.
Fixed Site	Beddingham	458059	600	183	−	−	Site Variation Factor −13·5 dB			Open site at crest of hill.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW ERP)

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN OTTRINGHAM AREA
TRANSMISSION FROM PONTOP PIKE — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square TA)	Site Height (a.m.s.l.)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Nr. Thorngumbald	208255	10	3·0	4·5	7·2	+4·5	−1·2	+5·7	Flat ground in all directions.
2	Nr. Ryhill	231261	25	7·6	3·2	5·2	+4·9	+1·0	+3·9	Open ground, trees at rear and sides of aerial. Telephone wires at rear.
3	The Colony	296263	88	26·8	1·75	2·8	+4·0	+0·7	+3·3	Flat, open ground. Trees 100 ft to rear.
4	Hallfield	213292	35	10·6	5·2	8·4	+5·2	+1·0	+3·2	Open ground, dropping slightly in front of aerial. Slight undulations to horizon. Farm buildings 50 yd to rear.
5	Nr. Patrington	327218	45	13·7	3·3	5·3	+9·5	+8·5	+1·0	Open ground, slightly undulating. Trees ¼-mile in front.
6	Nr. Keyingham Grange	240231	15	4·5	2·5	4·0	+1·5	+0·5	+1·0	Flat. Farm buildings ¼-mile in front. Telephone wires 25 yd at rear.
7	Weldons Plantation	308248	50	15·2	1·9	3·1	+3·0	+2·5	+0·5	Flat ground. Trees at 1 mile.
8	Nr. North End Farm	275262	20	6·1	1·3	2·1	−1·0	0	−1·0	Flat, open site.
9	The Shrubbery	262211	10	3·0	2·1	3·4	+4·2	+5·2	−1·0	Flat ground. Farm ¼ mile at rear. Telephone wires 15 yd to right, also trees.
10	Eastgrowths Farm	301205	14	4·2	2·6	4·2	−2·5	−1·5	−1·0	Flat ground. House 15 yd to right.
11	Waxholme	327301	50	15·2	4·8	7·7	−3·5	−2·2	−1·3	Open ground, sea to right and rear.
12	Bunkers Hill	291277	40	12·2	2·4	3·9	+10·0	+11·5	−1·5	Open fields at front rising to just over 50 ft at 350 yd. Trees on horizon.
13	Nr. Elmtree Cottage	259296	20	6·1	3·6	5·8	+3·0	+5·3	−2·3	Open ground, trees on horizon. Power lines at 200 yd (20 ft a.g.l.). House 600 yd in front.
14	Eastholme	252279	8	2·4	2·9	4·7	−2·0	+0·5	−2·5	Flat site. Ground rising to 40 ft at 2/3-mile. Trees at 250 yd.
15	Nr. Tunstall	297314	60	18·3	4·7	7·6	+8·0	+11·0	−3·0	Flat site, rising slightly to 70 ft at horizon. Trees on horizon.
16	Rimswell	318281	50	15·2	3·5	5·6	+0·5	+3·5	−3·0	Open ground rising slightly at front.
17	Nr. Mile House	326238	40	12·2	3·0	4·8	+11·5	+14·5	−3·3	Open ground rising to 80 ft at 1 mile with trees. Power lines (20 ft a.g.l.) at ¼-mile also 200 yd at rear.
18	Nr. Winestead White Hall	294242	25	7·6	1·0	1·6	+11·3	+16·0	−4·7	Open ground rising to 35 ft.
19	North Farm	350222	70	21·3	4·6	7·4	−7·5	+1·2	−8·7	Undulating ground to horizon.
20	Nr. The Elms	289294	10	3·0	3·4	5·5	−1·5	+8·0	−9·5	Tree lined road. Hill at 300 yd rising to 50 ft.
Fixed Site	Ottringham	279239	30	9·1	–	–	Site Variation Factor – 1·0 dB			Flat terrain at vicinity of site.

(Field strengths are expressed in dB relative to 1 μV/m for 1 kW ERP)

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN DORKET HEAD AREA
TRANSMISSION FROM PONTOP PIKE — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square SK)	Site Height (a.m.s.l.)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Davis's Bottom	494522	595	181	7·1	11·4	+5·0	−2·5	+7·5	Open site. Ground falling away in front of aerial.
2	Windmill Hill	522576	620	189	8·0	12·9	−2·0	−9·0	+7·0	Ground dropping gradually to 400 ft then rising at 2½ miles to 500 ft. Power line at 100 yd well below aerial.
3	Pilgrim Oak	558547	510	156	5·3	8·5	−2·0	−8·0	+6·0	Hill overlooking valley rising again to 500 ft about 2 miles. Trees to left and on facing hill summit. Power line 250 yd below aerial.
4	Malkin Hill	663410	200	61	5·6	9·0	−4·5	−8·0	+3·5	Flat ground, dropping slightly. Trees at ¼-mile.
5	Tollerton Bridge	608366	90	27	6·4	10·3	−3·5	−7·0	+3·5	Flat ground rising to 250 ft at 2 miles. Short bushy trees all round.
6	Nr. Blidworth	585557	500	152	5·4	8·7	−6·5	−9·5	+3·0	Undulating ground all round but not higher than site.
7	Arnold Lodge	604469	415	126	0·5	8·0	−5·0	−7·0	+2·0	Flat ground rising to 500 ft at 1 mile.
8	Oxtonhill Farm	647520	400	122	4·5	7·2	−9·5	−10·5	+1·0	Open site. Ground dropping gradually then rising to 400 ft at 1 mile. 20-ft power lines at 75 yd.
9	Dewbury Hill	657386	240	73	6·4	10·3	−5·0	−5·0	0	Flat site. Trees at 200 yd.
10	Ramsdale Park	598486	500	152	0·9	1·4	−8·0	−6·5	−1·5	On hill summit. Trees directly in front at 100 yd.
11	Lambley Cottage	610458	300	91	1·1	1·8	−10·0	−8·5	−1·5	Ground dropping slightly in front to just under 250 ft then rising to 400 ft at 1 mile.
12	Hundred Acres Farm	570483	390	119	1·8	2·9	−9·5	−7·5	−2·0	Flat, open ground dropping slightly at front.
13	Loath Hill	632540	365	111	4·8	7·7	−11·0	−9·0	−2·0	Ground rising slightly at front.
14	Thurgarton Farm	682501	190	58	5·6	9·0	−7·0	−3·5	−3·5	Open site. Rising gradually in front of aerial.
15	Nr. Epperstone	650479	100	30	3·4	5·5	−10·0	−5·0	−5·0	Fairly flat with few trees at 150 yd and 300 yd. Rising at 1 mile to 250 ft.
16	Hazel Hill	566458	360	110	2·0	3·2	−0·5	+4·5	−5·0	Open site. Undulating. Trees and buildings ½ mile in front.
17	Hempshill Hall	527440	275	84	5·6	9·0	−8·5	−2·5	−6·0	Rising ground to rear 300 yd. Building and trees ¼ mile in front.
18	Bulcote	663442	65	20	4·5	7·2	−8·0	−1·5	−6·5	Flat, open ground rising to 200 ft at ¾ mile.
19	Long Hill	518493	400	122	5·0	8·0	−16·5	−8·5	−8·0	Ground dropping gradually then rising to 500 ft at 1 mile. Trees on summit.
20	Nr. New Bridge	564368	80	24	6·6	10·6	−11·0	−1·0	−10·0	Pylons and wires ¼ mile in front of site. Large power station at 1/3-mile to right. Building at rear.
21	Porchester Rd. (Notts.)	593416	320	97	3·4	5·5	−19·5	−9·5	−10·0	Ground rising gradually in front. Hospital buildings (30 ft) at 250 yd.
Fixed Site	Dorket Head	596471	460	140	–	–	Site Variation Factor – 1·5 dB			Ground rising to 500 ft at a distance of 1 mile.

(Field Strengths are expressed in dB relative to $1 \mu V/m$ for 1 kW ERP)

SITE VARIATION FACTOR (S.V.F.) — MEASUREMENTS MADE IN MURSLEY AREA
TRANSMISSION FROM PONTOP PIKE — BAND III (180·4 Mc/s)

Test No.	Site Location	Grid Reference (100 km square SP)	Site Height (a.m.s.l.)		Distance from Permanent Site		Field Strength		Comparison of Field Strength of Temporary with Permanent Site (dB)	Site Details
			ft	m	ml	km	Temporary Site (dB)	Permanent Site (dB)		
1	Nr. Oving	785219	500	152	5·1	8·2	−4·0	−3·0	+1·0	Ground in front of aerial dropping to 300 ft then flat to horizon.
2	Whaddon	798344	350	107	3·7	6·0	−2·5	−2·5	0	Flat ground, few trees at 200 yd.
3	Nr. Singleborough	777323	420	128	3·5	5·6	+11.0	+12.0	−1.0	Ground in front of aerial dropping slightly.
4	Blacksfields Farm	762364	280	85	5·9	9·5	+4·0	+ 5·5	−1·5	Farm 40 yd to left. Ground falling slightly in front.
5	Loughton	829376	260	79	5·3	8·5	−9·0	−7·5	−1·5	Ground rising slightly in front of aerial.
6	Newton Longville	839316	320	97	1·8	2·9	−3·5	−1·5	−2·0	Open ground. Trees 100 yd at rear.
7	Nr. Soulbury	871268	460	140	3·3	5·3	−12·5	−10·0	−2·5	Ground dropping slightly in front of aerial.
8	Bletchley	871349	240	73	4·7	7·6	−10·5	−8·0	−2·5	Fairly flat. Trees at 200 yd.
9	East Claydon	736255	400	122	5·8	9·3	+5·0	+9·0	−4·0	Ground flat with a few trees ½-mile. Power line at 200 yd in front and 75 yd at rear.
10	Nr. Adstock	738311	350	107	5·5	8·8	+1·0	+5·0	−4·0	Fairly flat. Few trees.
11	Liscombe Park	883252	420	128	4·4	7·1	+5·5	+11·5	−6·0	Flat ground rising to 470 ft at 1 mile. Trees at 500 yd.
12	Stoke Hammond	875299	300	91	3·2	5·2	−6·0	+1·5	−7·5	Ground dropping slightly in front of aerial. Some trees at 200 yd. Large tree at rear.
13	Borough Farm	858310	330	100	2·4	3·9	−9·5	−1·5	−8·0	Flat ground in front of aerial, then gradual drop.
14	Potash Farm	833281	470	143	0·85	1·4	−4·5	+4·0	−8·5	Flat ground. Power line (20 ft a.g.l.) at rear.
15	Cublington	833216	350	107	4·6	7·4	−6·0	+3·0	−9·0	Ground rising in front of aerial. Trees at 100 and 400 yd.
16	Nr. Great Horwood	783313	450	137	2·9	4·7	+4·5	+14·0	−9·5	Flat ground with low hedge 50 yd in front.
17	Bennetts Hill	779265	315	96	3·2	5·2	−7·5	+6·5	−14·0	Rising ground in front of aerial. Trees.
Fixed Site	Mursley	825291	520	158	–	–	Site Variation Factor −5·0 dB			Open site at crest of gradually sloping terrain.

(Field strengths are expressed in dB relative to 1μV/m for 1 kW ERP)